Experimental Evaluation of the Suitability of Local Agro Materials as a Potential Alternative to Conventional Sodium Asphalt Sulfonate in Fluid Loss Control

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Abstract

The study focuses on using local agro materials as a possible filtration loss control in drilling muds. Colocasian esculenta (long cocoyam), Xanthosoma spp (short cocoyam) and Pennisetum glaucum (millet) were obtained as an alternative for the imported filtration loss control (soltex) used as drilling fluid additives. Oil based muds were formulated using the locally sourced agro materials and the conventional one (Soltex). Laboratory tests were carried out at different concentrations of 2g, 4g, 6g and 8g to determine the cake thickness and filtration loss control. The result of the study shows that Colocasianesculenta and Xanthosianspp showed a good filtration loss control at 2g, 4g, 6g and 8g when compared to existing one (soltex).

Keywords:

Agro materials,, Filtration loss**,** Colocasian esculenta, Pennisetum glaucum and Xanthosoma spp

1. Introduction

The need to use local agro biomaterials as possible filter loss control in drilling mud is important. There is no well drilled today without the use of drilling fluids. These fluids may vary in composition but their functions are the same. Some of these functions includes; transporting cuttings from the bottom of the well to the surface, keeping the drill bits and drill string cool, holding cuttings in suspension when mud circulation ceases and preventing formation fluids from prematurely gaining access into the wellbore. Drilling fluid must be selected and (or) designed so that the physical and chemical properties of the fluid allow these functions to be fulfilled.

2. Literature Review

Drilling fluids are designed to build a filter cake, this filter cake is intended to reduce filter loss to the formation and give a thin impermeable mud cake at wall of the wellbore. However, it should be noted that when a permeable formation is exposed to drilling mud during mud circulation, the liquid components of the mud would find its way into the formation while the solid components of the mud would build a thin cake of mud solids on the wellbore walls Kumar 2010

In addition, drilling fluids are also designed to reduce filtrate loss to the formation, form thin filter cakes that plaster the walls of the borehole to ensure minimal fluid loss to the formation and promote the stability of the drilled well. Annis 1996 noted that during overbalanced drilling operations, there are two mechanisms that are paramount for the filter cake build upprocess. They are the static and dynamic filtration mechanisms. However, Adebayo 2012 in their research work noted that filtration of a dynamic nature essentially takes place while the mud circulation is in progress and static filtration takes place when the mud circulation stops. However there is a clear distinction between both filtration types. First, the mud flow reduces the cake thickness due to erosioneffects of the flow while the mud cake thickness grows in static filtration conditions. Igwe 2015 noted that at stable circulating temperatures, polymer can decompose to form residues when subjected to static reservoir temperatures for long period of time. Over time, there has been a shift from using commercial polymers to using agro-wastes containing cellulose as filtration loss control agents in drilling fluids. Dagwa 2012 observed that the use of biomaterials is attractive due to the numerous advantages it offers especially in the aspects of cost effectiveness and reducing environmental hazards. Okorie 2018 in their findings further enterprise the utilization of agro materials in drilling fluid formulation. In their research, they noted that the agro waste materials were historically used as lost circulation materials, and that a mixture of two or more agro waste materials prevents lost circulation better than when used alone. However, their review further showed that agro waste materials are low and inexpensive and could equally serve as possible filter loss control agents in drilling mud. Thus, their utilization as filter loss control agents in drilling mud helps reduce environmental pollution and ultimately reduce drilling fluid costs. Ademiluyi 2011 carried out a study and observed that local polymers have the ability to be used as an alternative to imported samples for fluid loss control. The higher the amount of fluid loss to the formation, the greater is the risk of pipe being differential sticking due to thick filter cake deposition in the wellbore wall. High solids concentrations due to poor solids removal during drilling also lead to thick filter cake and high filtrate volume. Adebayo also noted that the values of the cake thickness kept decreasing even as concentration of saw dust increased. This contrasts with the work of Okon 2014 where it is observed that the values of cake thickness increased with increase in rice husk concentration while the works of Anawe 2014 shows constant values of cake thickness as concentration of the fluid loss additive they used increased. These variations could largely be attributed to the differences in cellulosic material they used, the particle sizes as well as the temperature and pressure conditions under which the experiments were conducted. In addition, Chinwuba 2016 in their research noted that Pleurotus tuberregium performed poorly as a filter loss control agent and is thermally unstable. Ukachukwu 2010 noted in their research that millet starchholds good potential,as a filter loss control materials and observed high stable temperature. However, [8] observed increased concentration of starch corn reduces filtrate loss, thus can be used as filtrate loss control additives. In contrast, Saengdee 2017 noted that Sugarcane bagasseash reduce filtrate loss, and produce thin and consistent cakes, whereas the cake thickness and filter loss volumes increase with increasing temperature. Moreover, Igwilo 2017 observed that Annona muricata and Carica papaya can be used as fluid loss control additives for water based mud. However, Annona muricata performed better than Carica papaya in controlling fluid loss. Dewan 2001 in their research enumerated the importance of a thin filter cake. They noted that the description of the quality of the filter cake is important since a mud engineer reports them, and records it on the mud report along with filtrate volume and cake thickness.

Table 1 A comprehensive performance of the proposed additive and other additives used in the literature [14].

Authors	Materials used	Property of Material studied	Performance/Findings
Adebayo and Chinonyere(2012)	Saw Dust	Filter loss and density	Large sizes of sawdust particles controlled filter loss better than smaller sized particles though the cakes obtained with large particle

			sizes are unstable
Okon et al. (2014)	Rice husk	Filter loss and Filter cake thickness	The rice husk reduced filter loss to an extent comparable to poly anionic cellulose (PAC)
Anawe Paul et al. (2014)	Rice husk and Saw dust	Filter loss	For rice husk to be used as filter loss agent in OBMs, modifications should be made for a desirable mud cake thickness to be achieved
Igwilo et al. (2017)	Annonamuricata and Carica papaya	Filter loss	Annona muricata and Carica papaya can be used as fluid loss control additives for WBMs, however in comparison, Annonamuricata performed better than Carica papaya in controlling fluid loss
Saengdee and Terakulsatit (2017)	Sugar cane begasse ash	Filter loss	Sugarcane bagasse ash reduced filtrate loss and produced thin and constituent cakes; however the cake thickness and filter loss volumes increased with increasing temperature
Chinwuba et al. (2016)	Pleurotus tuber-reguim	Fluid loss and cake thickness	The Pleurotus tuber reguim performed poorly as a filter loss control agent. It is not available and is thermally unstable
Izuwa et al. (2019)	Colocasiaspp + Pennisetumglaucum	Fluid loss and cake thickness	The Colocasia esculenta performed better than Xanthosoma spp, while Pennisetum glaucum is poor in term of fluid loss control. However, cake thickness and filter loss volume decreased with increase in temperature. it is thermally stable

Table 2 Characteristic of the proposed additive at high temperature and salinity

Authors	Research study	Characteristic of proposed materials/Research findings
Yunista et al 2012	Molecular structure and thermal property of Taro starch (Colocasianspp)	Strong molecular binding forces in the starch granules of Colocasia spp ensure it is thermally stable
Lestari et al 2018	Corrosion resistant of Colocasianesculenta	Presence of polyphenol binding the hydroxyl group in Colocasiaspp enables it to thrive in a saline environment
Nyman et al 1989	Organic and inorganic constituent of Colocasianesculenta	Increased levels of Calcium oxalate, cholorophll, protein and some secondary alkaloids presence are responsible for the high tolerance of Colocasiaspp in a high saline environment
Uma et al 2010.	Plant signal behavior	The heat shock protein from pennisetumglaucum is a thermostable protein and retains its chaperones at higher temperature

3. Methodology

3.1 Preparation of the local agro materials

The local agro materials used for this study were collected from the south easternpart of Nigeria. The agro materials used for the filtration loss control are: Colocasianesculenta (long cocoyam), Xanthooma spp (short cocoyam) and Pennisetum glaucum (millet) as shown in Figures 1, 2 and 3 below while figure 5 and 6 is the grounded form of the proposed additives.

Figure 1 Colocasia esculenta (long cocoyam)

Figure 2 Xanthosoma spp (short cocoyam)

Figure 3 Pennisetum glaucum (millet)

The Colocasia esulenta, Xanthosoma spp and Pennisetum glaucum were peeled to remove the outer skin and sliced into pieces using a stainless steel knife after being washed to prevent bacterial attack. It was then dried in an oven for 3 hours at 45^{0}C. It was grounded using an electric blender, sieved and re-grounded until a finer particle size was obtained,to ensure sample homogeneity and reduce uncertainty of particle size, the particles were sieved to a particle size of 125microns and were subsequently stored in plastic bags at room temperature.

Figure 4 Grounded sample of Colocasia spp

Figure 5 Grounded sample of Pennisetum glaucum (millet)

3.2 Formulation of the mud samples

The local additives namely: Colocasia esulenta, Xanthosoma spp and Pennisetum glaucum were used to formulate the three samples of a synthetic drilling mud based on the American Petroleum Institute (API) standards. The fourth sample was formulated using sodium asphalt sulfonate (Soltex), which is the fluid loss control sample. Each sample was mixed using a standard Hamilton Beach commercial high-speed mixer and a bottom mixer cup shown in figure 6. Each additive to the mud was weighed, and gently introduced into the base fluid while the impeller was mixing. To prevent the loss of fluid, each sample was mixed for a specified amount of time and following the mixing order as shown in Table 1. The three mud samples formulated using Colocasia esulenta, Xanthosoma spp and Pennisetum glaucum were added in increments of 2g up to a maximum of 8g. The mud density for each of the samples was maintained at 10.5ppg. Figure 7 is the sample of the mud used in the laboratory work.

Figure 6 Hamilton beach mixer with the formulated mud

Figure 7 Samples of the formulated mud

Table 3 SYNETHTIC BASED MUD FORMULATION

Mud Weight: 10.5 ppg	**Oil/water ratio**	**75/25**		**Mud Type (SYNETHTIC BASED MUD) OBM (OIL BASED MUD)**			
Product	**Company brand name**	**S.G**	**Unit size**	**Mixing order**	**Mixing time (mins)**	**Product Concentration for 1 Lab bbl (350 mls)**	
						GRAMS	**MLS**
Base oil	EDC -99	0.80	bbl	1	4	164.7	200.9
Organophilic clay		1.70	lb			6.6	3.88
Viscosity modifier		0.95	Lb			1	1.1
Lime	MIL – LIME TM	2.3	Kg			5	2.17
Primary emulsifier		0.9	Gal	2	2	3	3.2
Secondary emulsifier		0.93				2	2.15
Aqueous phase	Water	1	bbl	3	5	90.82	90.70
Brine phase calcium chloride	$CaCl_2$ (98%)	2.2	Kg			28.9	13.1
Bridging agent (barite)	FLOW-CARB	4.1	Kg	4	5	134.9	29.5
Fluid loss additive		1.3	Lb	5	6	5	3.3
						441.92	**350.0**

3.2.1 List of Apparatus used in the experiment

The equipments used in the course of the experiments include:

(i) HPHT Filter press (ii) Hamilton beach Mixer and cup (iii) Electrical Stability Meter (ES) (iv) Weighing Balance(v) Beakers(vi) Filter Paper (vii) Stop watch(viii) Measuring Cylinder (ix) Electric Grinder(x) Oven (xi) Mud balance (xii) Spatula (xiii) Fan Viscometer

3.2.2 Procedures for Oil Based Mud

The API recommended practice for HPHT filter loss test adopted from API RP 13B-1 (American Petroleum Institute, 2003) was strictly followed during this research study. The API standard HPHT filtration test was carried out at 250°F and 500 psi pressure for thirty (30) minutes. The HPHT filter press consisting of cylindrical cell 3-inches in internal diameter and 5-inches high to contain the formulated drilling mud was used (plate 8) . The bottom of the cell was fitted with a sheet of hardened low ash grade filter paper and filled with the mud sample to be measured. However, after the necessary connections, a pressure of 500 psi from air compressor pump was supplied to the top of the cells using a back pressure regulator attached to a nitrogen tank. With a 25 ml graduated cylinder placed beneath the cell, the filtrate through the filter paper was collected over a period of 30 minutes and recorded in milliliters (mL). Since HPHT filter cells are usually half of the standard filter area, thus the volume obtained was doubled before reporting it as the API filtrate loss of the mud samples formulated with Colocasia esulenta, Xanthosoma spp and Pennisetum glaucum. Furthermore, it was placed on the fan viscometer to know the viscosity of the mud and electrical stability. The concentration of the formulated samples was measured at 2g, 4g, 6g and 8g using a mud balance. The mud balance helps to know the weight of the additive to be added.The same process is done repeatedly to all the three additives used in the process as well as the control sample which is the sodium asphalt sulfonate (Soltex). Table 2 and 3 shows the result of the laboratory analysis, while Figure 9 shows the graph of fluid loss volume against the concentration of both the proposed additives and conventional one (soltex).

Plate 8 HPHT filter press used in the experiment

4. Result and Discussion

Table 4 HPHT Filter loss measurements for various concentrations of the local additives

	Concentration of local additives				
	Without Filtrate loss Control Additive	**2 g**	**4g**	**6g**	**8g**
Filter loss control additive	**HPHT filter loss volumes at 30 minutes (ml)**				
Sodium asphalt sulfonate (soltex) as control sample	11	3.8	3.4	2.8	2.2
Colocasianesculenta (cocoyam long)	11	4.0	3.7	3.2	2.8
Xanthosomaspp (cocoyam short)	11	4.2	4.0	3.7	3.4
Pennisetumglatum(millet)	11	5.2	5.1	4.9	4.8
Mud weight(lb/gal)		10.5	10.5	10.5	10.5

Table 5 Filter cake thickness measurements for various concentrations of local additives

	Concentration of local additives				
	Without Filtrate loss Control Additive	**2g**	**4g**	**6g**	**8g**

	Filter cake thickness (mm) 1/32nds				
Sodium asphalt sulfonate (soltex) as control sample	2	1	1	1	1
Colocasianesculenta (cocoyam long)	2	1	1	1	1
Xanthosian (cocoyam short)	2	1	1	1	1
Pennisetumglatum(millet)	2	1	1	1	1
Filtrate Volume Field Standard across the Reservoir (ml)		≤ 5	≤ 5	≤ 5	≤ 5

Synthetic Based Muds Additives Concentrations on Filtrate Volume for both existing and proposed additives

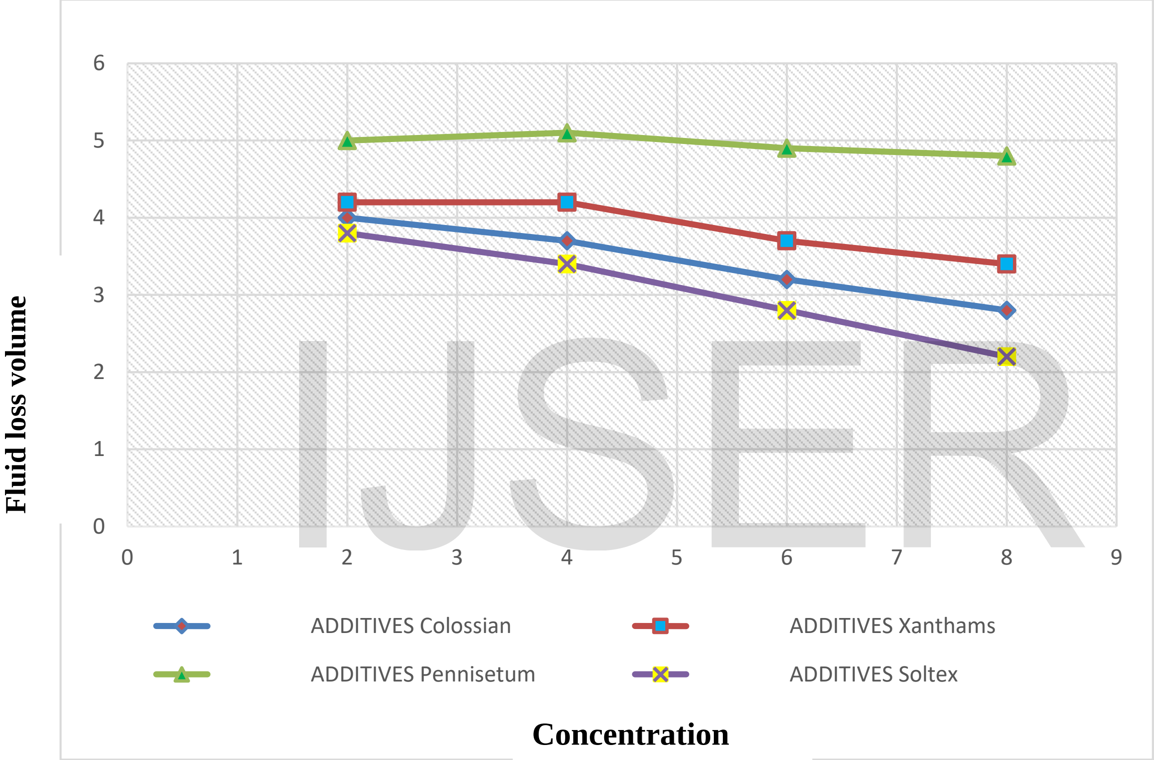

Figure 9 A graph showing fluid loss volume against concentration (both the proposed additive and existing additive)

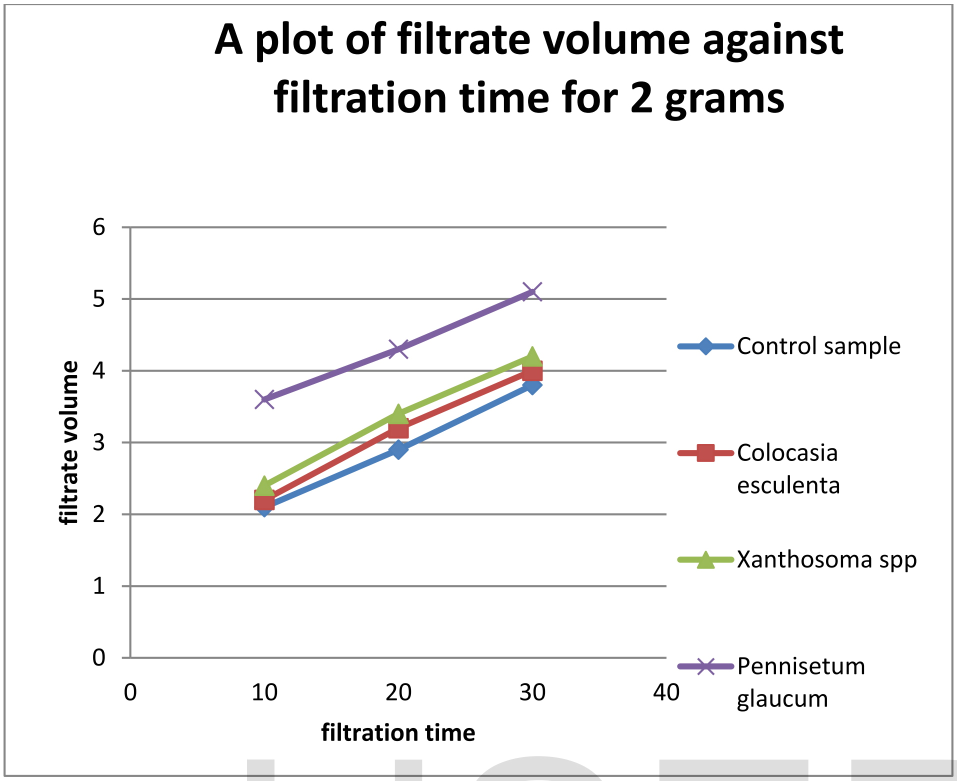

Figure 10 Filtrate volume against filtration time (2 grams)

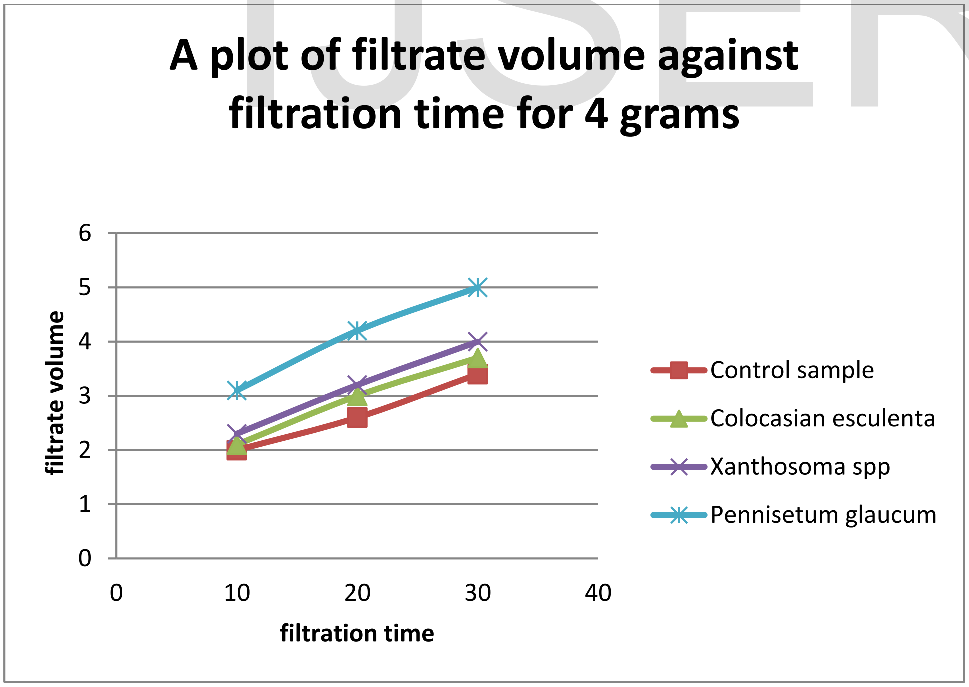

Figure 11 Filtrate volume against filtration time (4 grams)

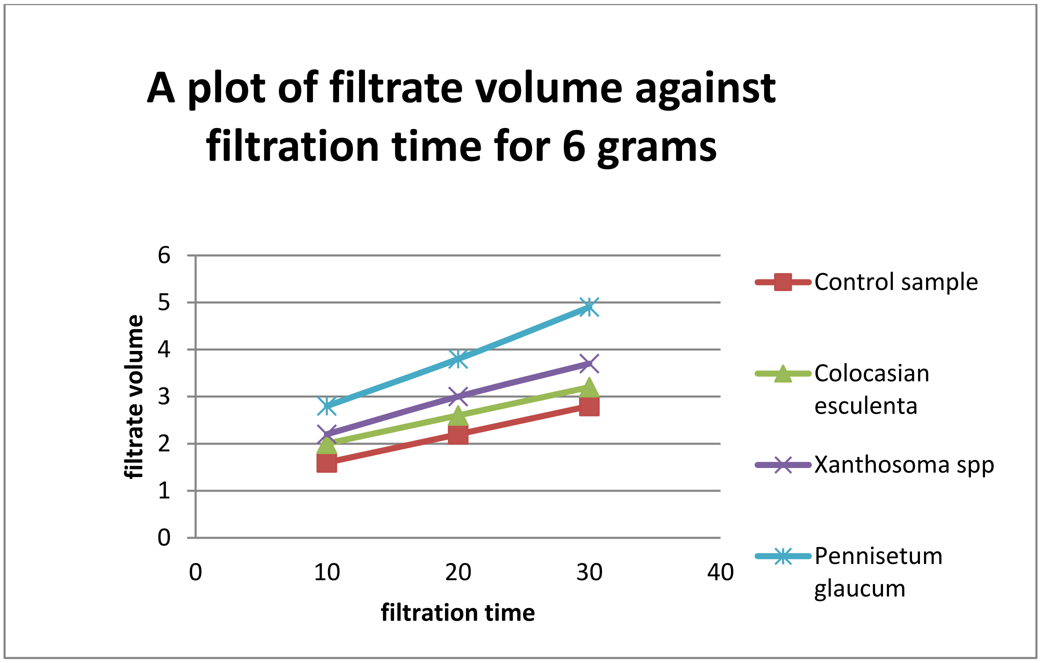

Figure 12 Filtrate volume against filtration time (6 grams)

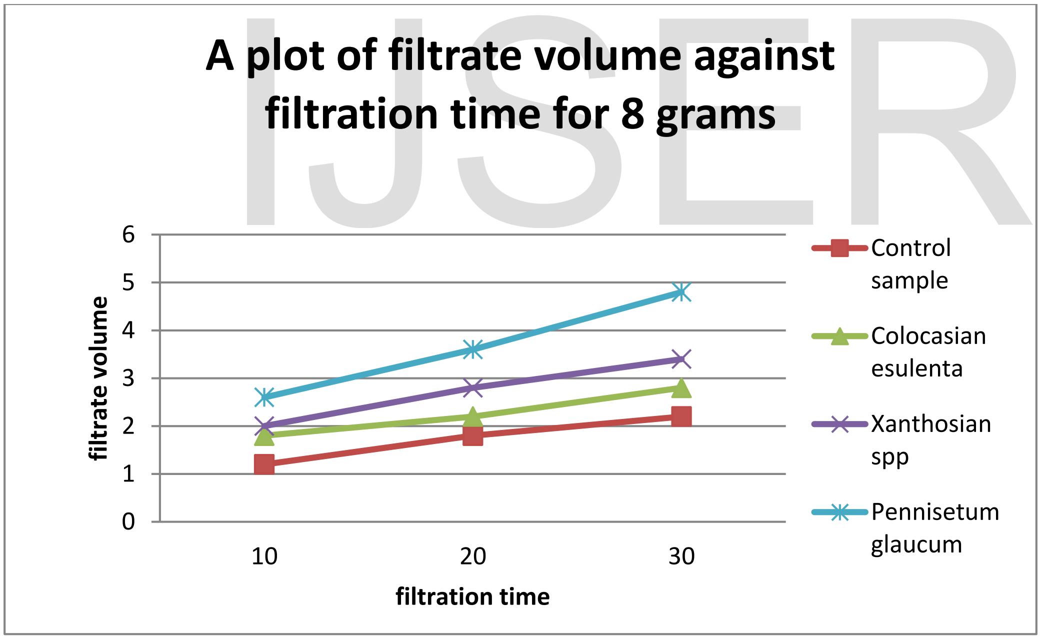

Figure 13 Filtrate volume against filtration time (8 grams)

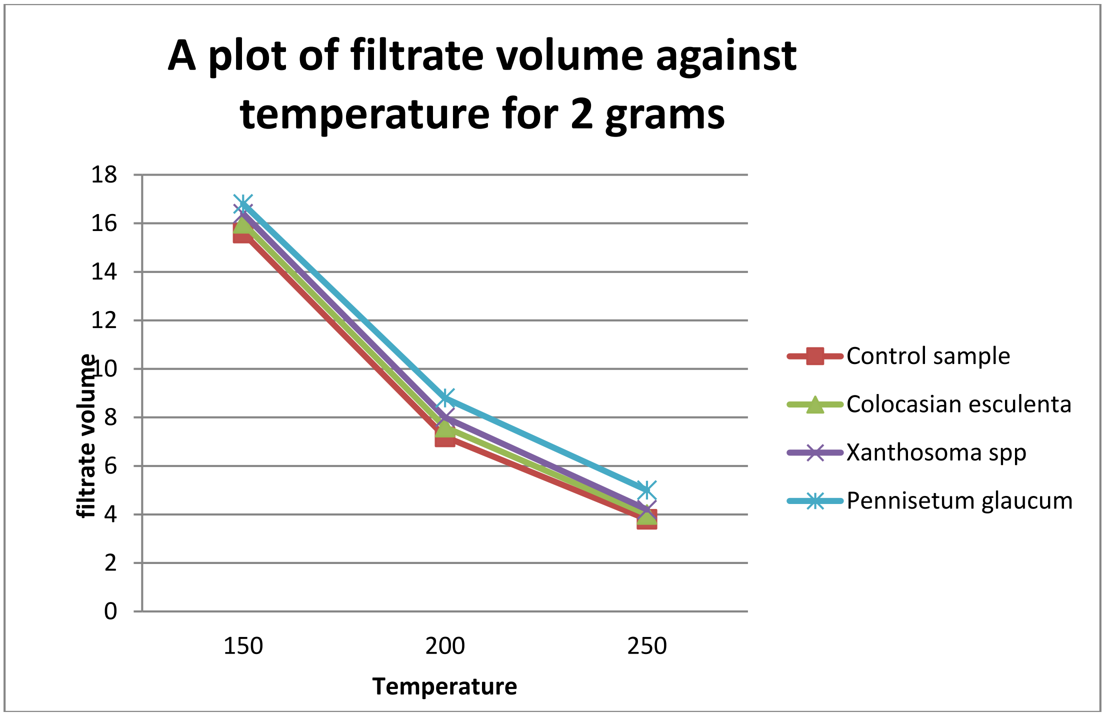

Figure 14 **A plot of filtrate volume against temperature (2 grams)**

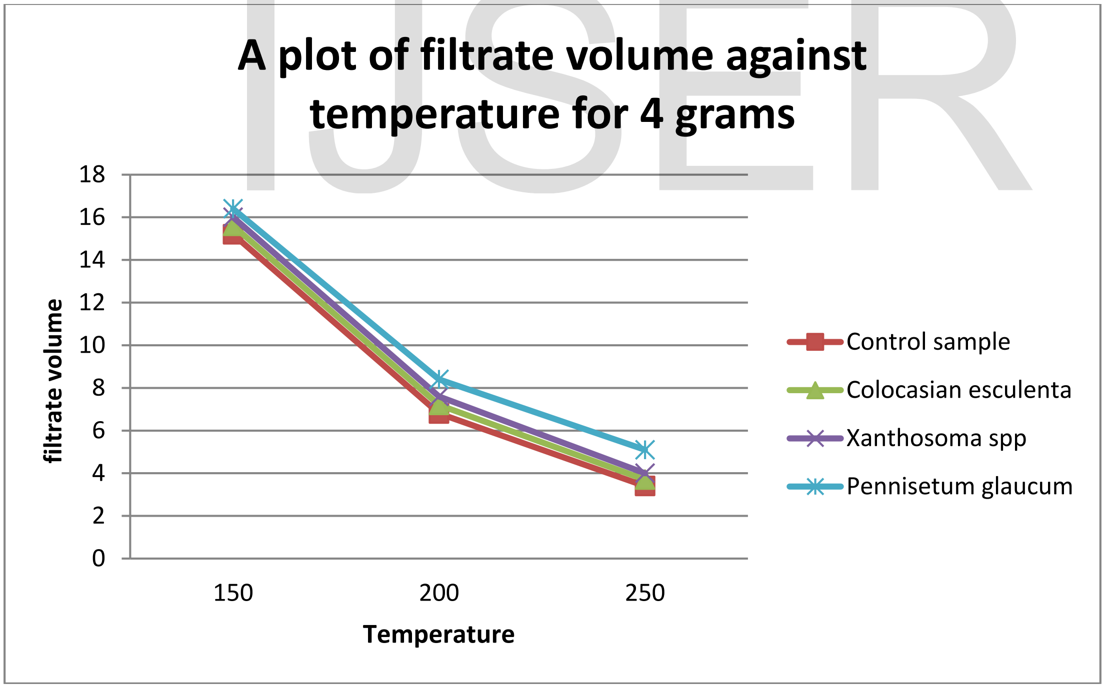

Figure 15 **A plot of filtrate volume against temperature (4 grams)**

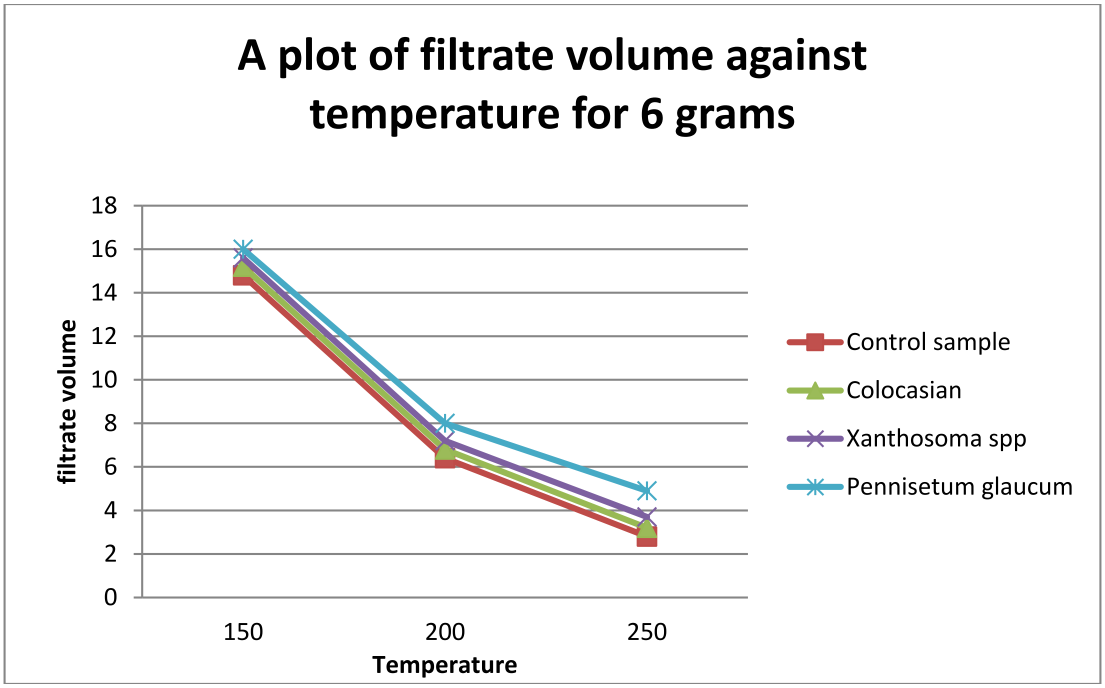

Figure 16 A plot of filtrate volume against temperature (6 grams)

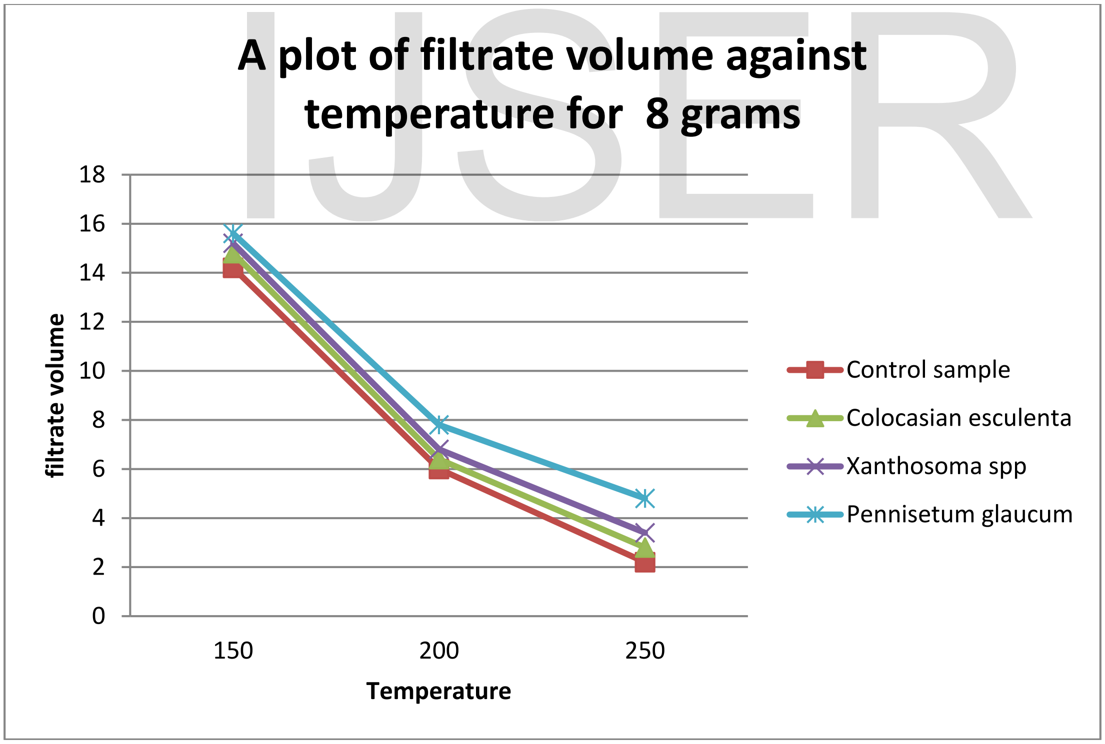

Figure 17 A plot of filtrate volume against temperature (8 grams)

4.2 Discussion

4.2.1 Filter cake thickness

Table 3 shows the formulation of the oil based mud. In Table 5, it can be observed that the filter cake measurements for muds formulated with Colocasia esculenta sample B, Xanthosoma spp sample C and Pennisetum glaucum sample D showed a consistent thickness across board for all the samples with a value of 1mm for all the various concentrations of the proposed additives. This is a clear indication that the filter cake thickness is not affected by changes in concentration of the proposed additives added as fluid loss additives. It is important to note that the API requirement of mud cake thickness of less than 2 mm was met according to API standard. However, the cake thickness indicates that muds formulated with Colocasian esculenta (sample B), Xanthosoma spp (sample C) and Pennisetum glaucum (sample D) as fluid loss additives would most likely not lead to drilling challenges such as differential pipe sticking, lost circulation and high torque during drilling operations but can serve as possible alternative to conventional sodium asphalt sulfonate (soltex).

4.2.2 Filtration loss results

In table 2, Itwas observed that the filtrate loss volumes across all samples decreases linearlyas theirconcentration increases. In addition, it was observed that out of the three proposed additives, sample B was appreciably better than sample C and D, as it showed a better filter loss control capability in comparison with the existing additive (control sample). These proposed additives were able to control filtration loss even at low concentrations of 2g to a filter volume of 4ml.

In addition, since the tests were carried out at HPHT conditions, it is safe to say that their stability at high temperatures and pressures is okay. Finally, Colocasian esculenta (sample B) and Xanthosoma spp (sample C) can be used as an alternative to the conventional soltex. It was observed in Figure 9 that the proposed additives showed a close match meaning it can be suitable for use as fluid loss control. In Figure 10-13 it can be observed that filtrate volume increases linearly against fixed time of 30 min. In addition, figure 14-17 shows that the filtrate volume reduces at high temperature of 250°F.

5. Conclusion

Based on the researched study conducted on the proposed additives, the following conclusions are drawn:

i.Colocasian esculenta (sample B) is a potential filtration loss control additive for drilling muds followed by Xanthosoma spp (sample C) while Pennisetum glaucum (sample D) performed poorly in term of filtration loss control.

ii.The fluid loss control capability of the proposed additives was noticeably increased when its concentration in the mud increased while the fluid loss volumes decreased linearly.
iii. The high cost of oil industry operations as a result of low oil price of crude. The use of agro wastes aspossible alternative for filter loss control materials would reduce drilling fluid costs.

6. Contribution to knowledge

The work investigated the suitability of Colocasia esculenta, Xanthosoma spp and Pennisetum glaucum as oil based drilling fluids additives using varied concentration of high temperature and high pressure filter press to establish fluid loss control effect

Conflict of interest: No Conflict of interest exist

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APPENDIX A

Table of filtrate volume and filtration time for 2g, 4g, 6g and 8g.

2 GRAMS

TIME	10 mins	20 mins	30 mins
SAMPLE A	2.1	2.9	3.8
SAMPLE B	2.2	3.2	4.0
SAMPLE C	2.4	3.4	4.2
SAMPLE D	3.6	4.3	5.1

4 GRAMS

TIME	10 mins	20 mins	30 mins
SAMPLE A	2.0	2.6	3.4
SAMPLE B	2.1	3.0	3.7
SAMPLE C	2.3	3.2	4.0
SAMPLE D	3.1	4.2	5.0

6 GRAMS

TIME	10 mins	20 mins	30 mins
SAMPLE A	1.6	2.2	2.8
SAMPLE B	2.0	2.6	3.2
SAMPLE C	2.2	3.0	3.7
SAMPLE D	2.8	3.8	4.9

8 GRAMS

TIME	10 mins	20 mins	30 mins
SAMPLE A	1.2	1.8	2.2
SAMPLE B	1.8	2.2	2.8
SAMPLE C	2.0	2.8	3.4
SAMPLE D	2.6	3.6	4.8

APPENDIX B

Table for filtrate volume and Temperature for 2g, 4g, 6g and 8g

2 GRAMS

TEMPERATURE	150°C	200°C	250°C
SAMPLE A	15.6	7.2	3.8
SAMPLE B	16.0	7.6	4.0
SAMPLE C	16.4	8.0	4.2
SAMPLE D	16.8	8.8	5.2

4 GRAMS

TEMPERATURE	150°C	200°C	250°C
SAMPLE A	15.2	6.8	3.4
SAMPLE B	15.6	7.2	3.7
SAMPLE C	16.0	7.6	4.0
SAMPLE D	16.4	8.4	5.1

6 GRAMS

TEMPERATURE	150°C	200°C	250°C
SAMPLE A	14.8	6.4	2.8
SAMPLE B	15.2	6.8	3.2
SAMPLE C	15.6	7.2	3.7
SAMPLE D	16.0	8.0	4.9

8 GRAMS

TEMPERATURE	150°C	200°C	250°C
SAMPLE A	14.2	6.0	2.2
SAMPLE B	14.8	6.4	2.8
SAMPLE C	15.2	6.8	3.4
SAMPLE D	15.6	7.8	4.8